

## Features

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 20 MIPS Throughput at 20 MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory Segments
  - 8K Bytes of In-System Self-Programmable Flash program memory (ATmega88PA)
  - 512 Bytes EEPROM (ATmega88PA)
  - 1K Bytes Internal SRAM (ATmega88PA)
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C<sup>(1)</sup>
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    - Temperature Measurement
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Byte-oriented 2-wire Serial Interface (Philips I<sup>2</sup>C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V for ATmega88PA
- Temperature Range:
  - -40°C to 85°C
- Speed Grade:
  - 0 - 20 MHz @ 1.8 - 5.5V
- Low Power Consumption at 1 MHz, 1.8V, 25°C for ATmega88PA:
  - Active Mode: 0.2 mA
  - Power-down Mode: 0.1 µA
  - Power-save Mode: 0.75 µA (Including 32 kHz RTC)



## 8-bit AVR® Microcontroller with 8K Bytes In-System Programmable Flash

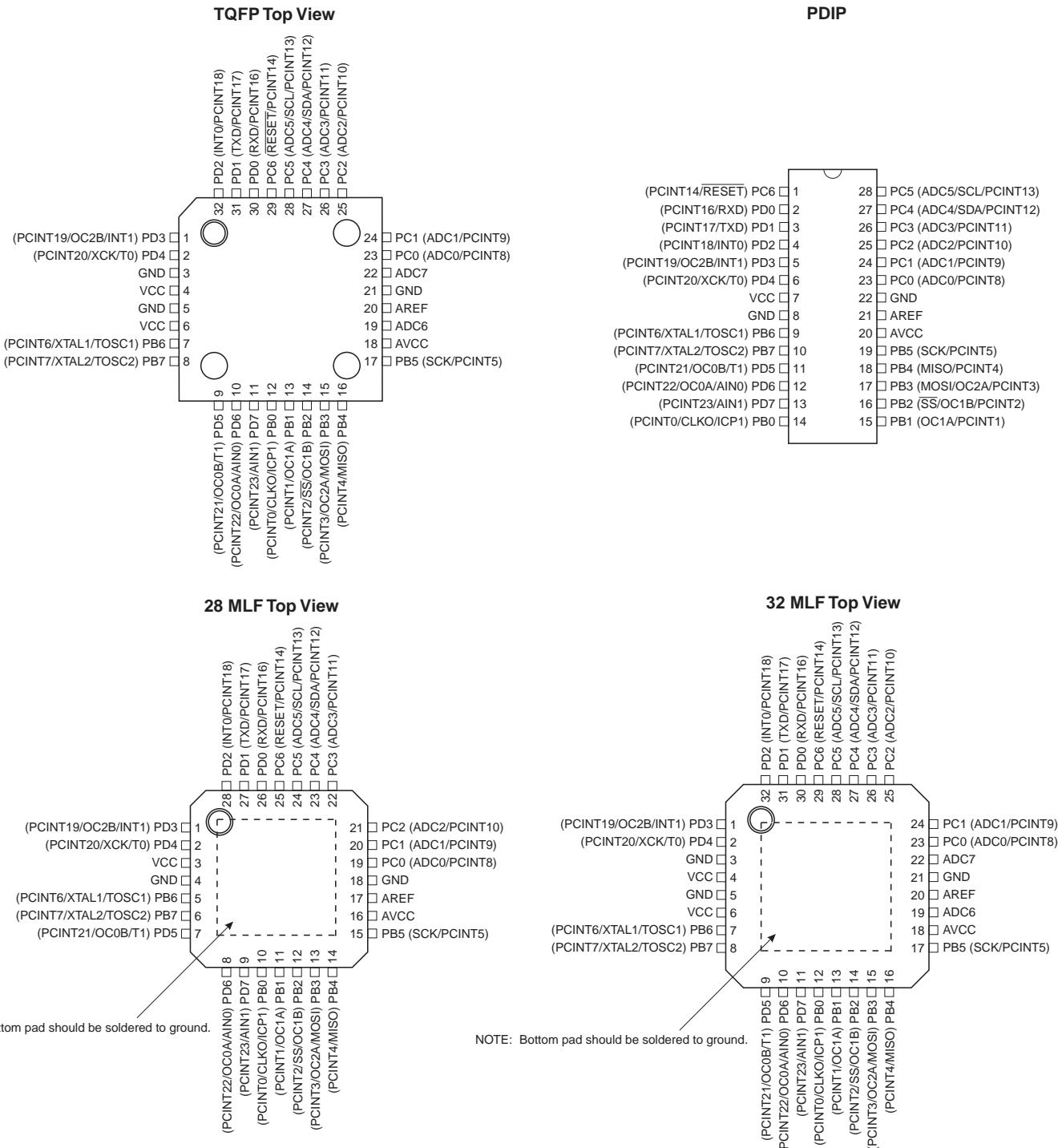
## ATmega88PA

## Summary



## 1. Pin Configurations

**Figure 1-1.** Pinout ATmega88PA



## 1.1 Pin Descriptions

### 1.1.1 VCC

Digital supply voltage.

### 1.1.2 GND

Ground.

### 1.1.3 Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB7..6 is used as TOSC2..1 input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

The various special features of Port B are elaborated in "[Alternate Functions of Port B](#)" on page [74](#) and "[System Clock and Clock Options](#)" on page [26](#).

### 1.1.4 Port C (PC5:0)

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5..0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

### 1.1.5 PC6/RESET

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. The minimum pulse length is given in [Table 27-3 on page 299](#). Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port C are elaborated in "[Alternate Functions of Port C](#)" on page [77](#).

### 1.1.6 Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.



The various special features of Port D are elaborated in "[Alternate Functions of Port D](#)" on page 80.

## 1.1.7 AV<sub>CC</sub>

AV<sub>CC</sub> is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to V<sub>CC</sub>, even if the ADC is not used. If the ADC is used, it should be connected to V<sub>CC</sub> through a low-pass filter. Note that PC6..4 use digital supply voltage, V<sub>CC</sub>.

## 1.1.8 AREF

AREF is the analog reference pin for the A/D Converter.

## 1.1.9 ADC7:6 (TQFP and QFN/MLF Package Only)

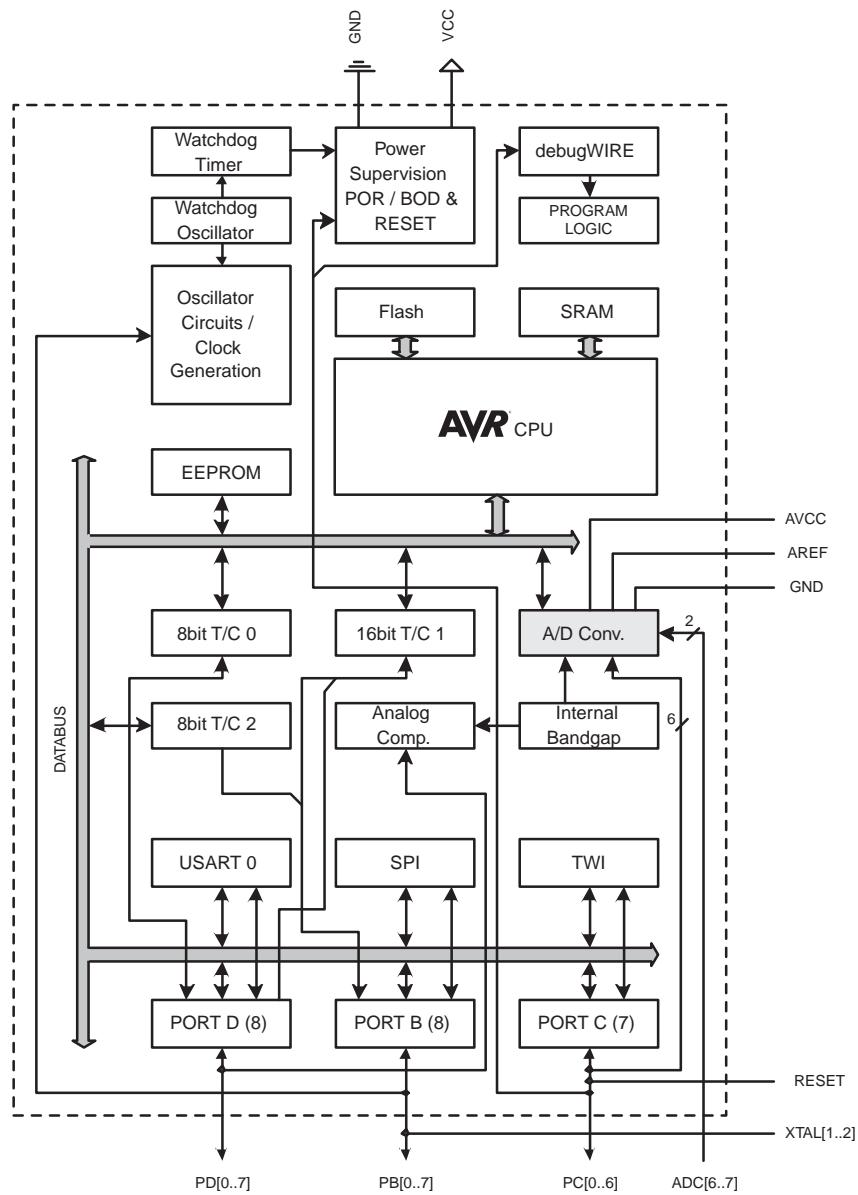
In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

## 2. Overview

The ATmega88PA is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega88PA achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

### 2.1 Block Diagram

**Figure 2-1.** Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting

architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega88PA provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes EEPROM, 1K bytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented 2-wire Serial Interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable Watchdog Timer with internal Oscillator, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, USART, 2-wire Serial Interface, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption.

The device is manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega88PA is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega88PA AVR is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators, In-Circuit Emulators, and Evaluation kits.

## 3. Resources

A comprehensive set of development tools, application notes and datasheets are available for download on <http://www.atmel.com/avr>.

## 4. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C or 100 years at 25°C.

## 5. Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xFF)	Reserved	—	—	—	—	—	—	—	—	
(0xFE)	Reserved	—	—	—	—	—	—	—	—	
(0xFD)	Reserved	—	—	—	—	—	—	—	—	
(0xFC)	Reserved	—	—	—	—	—	—	—	—	
(0xFB)	Reserved	—	—	—	—	—	—	—	—	
(0xFA)	Reserved	—	—	—	—	—	—	—	—	
(0xF9)	Reserved	—	—	—	—	—	—	—	—	
(0xF8)	Reserved	—	—	—	—	—	—	—	—	
(0xF7)	Reserved	—	—	—	—	—	—	—	—	
(0xF6)	Reserved	—	—	—	—	—	—	—	—	
(0xF5)	Reserved	—	—	—	—	—	—	—	—	
(0xF4)	Reserved	—	—	—	—	—	—	—	—	
(0xF3)	Reserved	—	—	—	—	—	—	—	—	
(0xF2)	Reserved	—	—	—	—	—	—	—	—	
(0xF1)	Reserved	—	—	—	—	—	—	—	—	
(0xF0)	Reserved	—	—	—	—	—	—	—	—	
(0xEF)	Reserved	—	—	—	—	—	—	—	—	
(0xEE)	Reserved	—	—	—	—	—	—	—	—	
(0xED)	Reserved	—	—	—	—	—	—	—	—	
(0xEC)	Reserved	—	—	—	—	—	—	—	—	
(0xEB)	Reserved	—	—	—	—	—	—	—	—	
(0xEA)	Reserved	—	—	—	—	—	—	—	—	
(0xE9)	Reserved	—	—	—	—	—	—	—	—	
(0xE8)	Reserved	—	—	—	—	—	—	—	—	
(0xE7)	Reserved	—	—	—	—	—	—	—	—	
(0xE6)	Reserved	—	—	—	—	—	—	—	—	
(0xE5)	Reserved	—	—	—	—	—	—	—	—	
(0xE4)	Reserved	—	—	—	—	—	—	—	—	
(0xE3)	Reserved	—	—	—	—	—	—	—	—	
(0xE2)	Reserved	—	—	—	—	—	—	—	—	
(0xE1)	Reserved	—	—	—	—	—	—	—	—	
(0xE0)	Reserved	—	—	—	—	—	—	—	—	
(0xDF)	Reserved	—	—	—	—	—	—	—	—	
(0xDE)	Reserved	—	—	—	—	—	—	—	—	
(0xDD)	Reserved	—	—	—	—	—	—	—	—	
(0xDC)	Reserved	—	—	—	—	—	—	—	—	
(0xDB)	Reserved	—	—	—	—	—	—	—	—	
(0xDA)	Reserved	—	—	—	—	—	—	—	—	
(0xD9)	Reserved	—	—	—	—	—	—	—	—	
(0xD8)	Reserved	—	—	—	—	—	—	—	—	
(0xD7)	Reserved	—	—	—	—	—	—	—	—	
(0xD6)	Reserved	—	—	—	—	—	—	—	—	
(0xD5)	Reserved	—	—	—	—	—	—	—	—	
(0xD4)	Reserved	—	—	—	—	—	—	—	—	
(0xD3)	Reserved	—	—	—	—	—	—	—	—	
(0xD2)	Reserved	—	—	—	—	—	—	—	—	
(0xD1)	Reserved	—	—	—	—	—	—	—	—	
(0xD0)	Reserved	—	—	—	—	—	—	—	—	
(0xCF)	Reserved	—	—	—	—	—	—	—	—	
(0xCE)	Reserved	—	—	—	—	—	—	—	—	
(0xCD)	Reserved	—	—	—	—	—	—	—	—	
(0xCC)	Reserved	—	—	—	—	—	—	—	—	
(0xCB)	Reserved	—	—	—	—	—	—	—	—	
(0xCA)	Reserved	—	—	—	—	—	—	—	—	
(0xC9)	Reserved	—	—	—	—	—	—	—	—	
(0xC8)	Reserved	—	—	—	—	—	—	—	—	
(0xC7)	Reserved	—	—	—	—	—	—	—	—	
(0xC6)	UDR0	USART I/O Data Register								187
(0xC5)	UBRR0H	USART Baud Rate Register High								191
(0xC4)	UBRR0L	USART Baud Rate Register Low								191
(0xC3)	Reserved	—	—	—	—	—	—	—	—	
(0xC2)	UCSR0C	UMSEL01	UMSEL00	UPM01	UPM00	USBS0	UCSZ01 /UDORD0	UCSZ00 /UCPHAO	UCPOL0	189/204



Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xC1)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXENO	TXENO	UCSZ02	RXB80	TXB80	188
(0xC0)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0	187
(0xBF)	Reserved	-	-	-	-	-	-	-	-	
(0xBE)	Reserved	-	-	-	-	-	-	-	-	
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	-	237
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	-	TWIE	234
(0xBB)	TWDR						2-wire Serial Interface Data Register			236
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	237
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	-	TWPS1	TWPS0	236
(0xB8)	TWBR						2-wire Serial Interface Bit Rate Register			234
(0xB7)	Reserved	-		-	-	-	-	-	-	
(0xB6)	ASSR	-	EXCLK	AS2	TCN2UB	OCR2AUB	OCR2BUB	TCR2AUB	TCR2BUB	156
(0xB5)	Reserved	-	-	-	-	-	-	-	-	
(0xB4)	OCR2B						Timer/Counter2 Output Compare Register B			154
(0xB3)	OCR2A						Timer/Counter2 Output Compare Register A			154
(0xB2)	TCNT2						Timer/Counter2 (8-bit)			154
(0xB1)	TCCR2B	FOC2A	FOC2B	-	-	WGM22	CS22	CS21	CS20	153
(0xB0)	TCCR2A	COM2A1	COM2A0	COM2B1	COM2B0	-	-	WGM21	WGM20	150
(0xAF)	Reserved	-	-	-	-	-	-	-	-	
(0xAE)	Reserved	-	-	-	-	-	-	-	-	
(0xAD)	Reserved	-	-	-	-	-	-	-	-	
(0xAC)	Reserved	-	-	-	-	-	-	-	-	
(0xAB)	Reserved	-	-	-	-	-	-	-	-	
(0xAA)	Reserved	-	-	-	-	-	-	-	-	
(0xA9)	Reserved	-	-	-	-	-	-	-	-	
(0xA8)	Reserved	-	-	-	-	-	-	-	-	
(0xA7)	Reserved	-	-	-	-	-	-	-	-	
(0xA6)	Reserved	-	-	-	-	-	-	-	-	
(0xA5)	Reserved	-	-	-	-	-	-	-	-	
(0xA4)	Reserved	-	-	-	-	-	-	-	-	
(0xA3)	Reserved	-	-	-	-	-	-	-	-	
(0xA2)	Reserved	-	-	-	-	-	-	-	-	
(0xA1)	Reserved	-	-	-	-	-	-	-	-	
(0xA0)	Reserved	-	-	-	-	-	-	-	-	
(0x9F)	Reserved	-	-	-	-	-	-	-	-	
(0x9E)	Reserved	-	-	-	-	-	-	-	-	
(0x9D)	Reserved	-	-	-	-	-	-	-	-	
(0x9C)	Reserved	-	-	-	-	-	-	-	-	
(0x9B)	Reserved	-	-	-	-	-	-	-	-	
(0x9A)	Reserved	-	-	-	-	-	-	-	-	
(0x99)	Reserved	-	-	-	-	-	-	-	-	
(0x98)	Reserved	-	-	-	-	-	-	-	-	
(0x97)	Reserved	-	-	-	-	-	-	-	-	
(0x96)	Reserved	-	-	-	-	-	-	-	-	
(0x95)	Reserved	-	-	-	-	-	-	-	-	
(0x94)	Reserved	-	-	-	-	-	-	-	-	
(0x93)	Reserved	-	-	-	-	-	-	-	-	
(0x92)	Reserved	-	-	-	-	-	-	-	-	
(0x91)	Reserved	-	-	-	-	-	-	-	-	
(0x90)	Reserved	-	-	-	-	-	-	-	-	
(0x8F)	Reserved	-	-	-	-	-	-	-	-	
(0x8E)	Reserved	-	-	-	-	-	-	-	-	
(0x8D)	Reserved	-	-	-	-	-	-	-	-	
(0x8C)	Reserved	-	-	-	-	-	-	-	-	
(0x8B)	OCR1BH									130
(0x8A)	OCR1BL									130
(0x89)	OCR1AH									130
(0x88)	OCR1AL									130
(0x87)	ICR1H									131
(0x86)	ICR1L									131
(0x85)	TCNT1H									130
(0x84)	TCNT1L									130
(0x83)	Reserved	-	-	-	-	-	-	-	-	
(0x82)	TCCR1C	FOC1A	FOC1B	-	-	-	-	-	-	129
(0x81)	TCCR1B	ICNC1	ICES1	-	WGM13	WGM12	CS12	CS11	CS10	128
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	-	-	WGM11	WGM10	126



Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0x7F)	DIDR1	—	—	—	—	—	—	AIN1D	AIN0D	242
(0x7E)	DIDR0	—	—	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D	259
(0x7D)	Reserved	—	—	—	—	—	—	—	—	
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	—	MUX3	MUX2	MUX1	MUX0	255
(0x7B)	ADCSRB	—	ACME	—	—	—	ADTS2	ADTS1	ADTS0	258
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	256
(0x79)	ADCH	ADC Data Register High byte								
(0x78)	ADCL	ADC Data Register Low byte								
(0x77)	Reserved	—	—	—	—	—	—	—	—	
(0x76)	Reserved	—	—	—	—	—	—	—	—	
(0x75)	Reserved	—	—	—	—	—	—	—	—	
(0x74)	Reserved	—	—	—	—	—	—	—	—	
(0x73)	Reserved	—	—	—	—	—	—	—	—	
(0x72)	Reserved	—	—	—	—	—	—	—	—	
(0x71)	Reserved	—	—	—	—	—	—	—	—	
(0x70)	TIMSK2	—	—	—	—	—	OCIE2B	OCIE2A	TOIE2	155
(0x6F)	TIMSK1	—	—	ICIE1	—	—	OCIE1B	OCIE1A	TOIE1	131
(0x6E)	TIMSK0	—	—	—	—	—	OCIE0B	OCIE0A	TOIE0	103
(0x6D)	PCMSK2	PCINT23	PCINT22	PCINT21	PCINT20	PCINT19	PCINT18	PCINT17	PCINT16	66
(0x6C)	PCMSK1	—	PCINT14	PCINT13	PCINT12	PCINT11	PCINT10	PCINT9	PCINT8	66
(0x6B)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0	66
(0x6A)	Reserved	—	—	—	—	—	—	—	—	
(0x69)	EICRA	—	—	—	—	ISC11	ISC10	ISC01	ISC00	63
(0x68)	PCICR	—	—	—	—	—	PCIE2	PCIE1	PCIE0	
(0x67)	Reserved	—	—	—	—	—	—	—	—	
(0x66)	OSCCAL	Oscillator Calibration Register								
(0x65)	Reserved	—	—	—	—	—	—	—	—	
(0x64)	PRR	PRTWI	PRTIM2	PRTIMO	—	PRTIM1	PRSPI	PRUSART0	PRADC	42
(0x63)	Reserved	—	—	—	—	—	—	—	—	
(0x62)	Reserved	—	—	—	—	—	—	—	—	
(0x61)	CLKPR	CLKPCE	—	—	—	CLKPS3	CLKPS2	CLKPS1	CLKPS0	37
(0x60)	WDTCSR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDP0	54
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	9
0x3E (0x5E)	SPH	—	—	—	—	—	(SP10) <sup>5</sup> .		SP9	SP8
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	12
0x3C (0x5C)	Reserved	—	—	—	—	—	—	—	—	
0x3B (0x5B)	Reserved	—	—	—	—	—	—	—	—	
0x3A (0x5A)	Reserved	—	—	—	—	—	—	—	—	
0x39 (0x59)	Reserved	—	—	—	—	—	—	—	—	
0x38 (0x58)	Reserved	—	—	—	—	—	—	—	—	
0x37 (0x57)	SPMCSR	SPMIE	(RWWSB) <sup>5</sup> .	—	(RWWRE) <sup>5</sup> .	BLBSET	PGWRT	PGERS	SELFPRGEN	275
0x36 (0x56)	Reserved	—	—	—	—	—	—	—	—	
0x35 (0x55)	MCUCR	—	BODS	BODSE	PUD	—	—	IVSEL	IVCE	44/60/84
0x34 (0x54)	MCUSR	—	—	—	—	WDRF	BORF	EXTRF	PORF	54
0x33 (0x53)	SMCR	—	—	—	—	SM2	SM1	SM0	SE	40
0x32 (0x52)	Reserved	—	—	—	—	—	—	—	—	
0x31 (0x51)	Reserved	—	—	—	—	—	—	—	—	
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	240
0x2F (0x4F)	Reserved	—	—	—	—	—	—	—	—	
0x2E (0x4E)	SPDR	SPI Data Register								
0x2D (0x4D)	SPSR	SPIF	WCOL	—	—	—	—	—	SPI2X	166
0x2C (0x4C)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	165
0x2B (0x4B)	GPIOR2	General Purpose I/O Register 2								
0x2A (0x4A)	GPIOR1	General Purpose I/O Register 1								
0x29 (0x49)	Reserved	—	—	—	—	—	—	—	—	
0x28 (0x48)	OCR0B	Timer/Counter0 Output Compare Register B								
0x27 (0x47)	OCR0A	Timer/Counter0 Output Compare Register A								
0x26 (0x46)	TCNT0	Timer/Counter0 (8-bit)								
0x25 (0x45)	TCCR0B	FOC0A	FOC0B	—	—	WGM02	CS02	CS01	CS00	
0x24 (0x44)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	—	—	WGM01	WGM00	
0x23 (0x43)	GTCCR	TSM	—	—	—	—	—	PSRASY	PSRSYNC	135/157
0x22 (0x42)	EEARH	(EEPROM Address Register High Byte) <sup>5</sup> .								
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte								
0x20 (0x40)	EEDR	EEPROM Data Register								
0x1F (0x3F)	ECCR	—	—	EEPM1	EEPM0	EERIE	EEMPE	EEPE	EERE	21
0x1E (0x3E)	GPIOR0	General Purpose I/O Register 0								



Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x1D (0x3D)	EIMSK	-	-	-	-	-	-	INT1	INT0	64
0x1C (0x3C)	EIFR	-	-	-	-	-	-	INTF1	INTF0	64
0x1B (0x3B)	PCIFR	-	-	-	-	-	-	PCIF2	PCIF1	PCIF0
0x1A (0x3A)	Reserved	-	-	-	-	-	-	-	-	
0x19 (0x39)	Reserved	-	-	-	-	-	-	-	-	
0x18 (0x38)	Reserved	-	-	-	-	-	-	-	-	
0x17 (0x37)	TIFR2	-	-	-	-	-	-	OCF2B	OCF2A	TOV2
0x16 (0x36)	TIFR1	-	-	-	ICF1	-	-	OCF1B	OCF1A	TOV1
0x15 (0x35)	TIFR0	-	-	-	-	-	-	OCF0B	OCF0A	TOV0
0x14 (0x34)	Reserved	-	-	-	-	-	-	-	-	
0x13 (0x33)	Reserved	-	-	-	-	-	-	-	-	
0x12 (0x32)	Reserved	-	-	-	-	-	-	-	-	
0x11 (0x31)	Reserved	-	-	-	-	-	-	-	-	
0x10 (0x30)	Reserved	-	-	-	-	-	-	-	-	
0x0F (0x2F)	Reserved	-	-	-	-	-	-	-	-	
0x0E (0x2E)	Reserved	-	-	-	-	-	-	-	-	
0x0D (0x2D)	Reserved	-	-	-	-	-	-	-	-	
0x0C (0x2C)	Reserved	-	-	-	-	-	-	-	-	
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	85
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	85
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	85
0x08 (0x28)	PORTC	-	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	84
0x07 (0x27)	DDRC	-	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	84
0x06 (0x26)	PINC	-	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINCO	84
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	84
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	84
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	84
0x02 (0x22)	Reserved	-	-	-	-	-	-	-	-	
0x01 (0x21)	Reserved	-	-	-	-	-	-	-	-	
0x0 (0x20)	Reserved	-	-	-	-	-	-	-	-	

- Note:
- For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
  - I/O Registers within the address range 0x00 - 0x1F are directly bit-accessible using the SBI and CBI instructions. In these registers, the value of single bits can be checked by using the SBIS and SBIC instructions.
  - Some of the Status Flags are cleared by writing a logical one to them. Note that, unlike most other AVR's, the CBI and SBI instructions will only operate on the specified bit, and can therefore be used on registers containing such Status Flags. The CBI and SBI instructions work with registers 0x00 to 0x1F only.
  - When using the I/O specific commands IN and OUT, the I/O addresses 0x00 - 0x3F must be used. When addressing I/O Registers as data space using LD and ST instructions, 0x20 must be added to these addresses. The ATmega88PA is a complex microcontroller with more peripheral units than can be supported within the 64 location reserved in Opcode for the IN and OUT instructions. For the Extended I/O space from 0x60 - 0xFF in SRAM, only the ST/STS/STD and LD/LDS/LDD instructions can be used.
  - Only valid for ATmega88PA/168PA.

## 6. Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
<b>ARITHMETIC AND LOGIC INSTRUCTIONS</b>					
ADD	Rd, Rr	Add two Registers	$Rd \leftarrow Rd + Rr$	Z,C,N,V,H	1
ADC	Rd, Rr	Add with Carry two Registers	$Rd \leftarrow Rd + Rr + C$	Z,C,N,V,H	1
ADIW	Rdl,K	Add Immediate to Word	$Rdh:Rdl \leftarrow Rdh:Rdl + K$	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract two Registers	$Rd \leftarrow Rd - Rr$	Z,C,N,V,H	1
SUBI	Rd, K	Subtract Constant from Register	$Rd \leftarrow Rd - K$	Z,C,N,V,H	1
SBC	Rd, Rr	Subtract with Carry two Registers	$Rd \leftarrow Rd - Rr - C$	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with Carry Constant from Reg.	$Rd \leftarrow Rd - K - C$	Z,C,N,V,H	1
SBIW	Rdl,K	Subtract Immediate from Word	$Rdh:Rdl \leftarrow Rdh:Rdl - K$	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND Registers	$Rd \leftarrow Rd \bullet Rr$	Z,N,V	1
ANDI	Rd, K	Logical AND Register and Constant	$Rd \leftarrow Rd \bullet K$	Z,N,V	1
OR	Rd, Rr	Logical OR Registers	$Rd \leftarrow Rd \vee Rr$	Z,N,V	1
ORI	Rd, K	Logical OR Register and Constant	$Rd \leftarrow Rd \vee K$	Z,N,V	1
EOR	Rd, Rr	Exclusive OR Registers	$Rd \leftarrow Rd \oplus Rr$	Z,N,V	1
COM	Rd	One's Complement	$Rd \leftarrow 0xFF - Rd$	Z,C,N,V	1

Mnemonics	Operands	Description	Operation	Flags	#Clocks
NEG	Rd	Two's Complement	$Rd \leftarrow 0x00 - Rd$	Z,C,N,V,H	1
SBR	Rd,K	Set Bit(s) in Register	$Rd \leftarrow Rd \vee K$	Z,N,V	1
CBR	Rd,K	Clear Bit(s) in Register	$Rd \leftarrow Rd \bullet (0xFF - K)$	Z,N,V	1
INC	Rd	Increment	$Rd \leftarrow Rd + 1$	Z,N,V	1
DEC	Rd	Decrement	$Rd \leftarrow Rd - 1$	Z,N,V	1
TST	Rd	Test for Zero or Minus	$Rd \leftarrow Rd \bullet Rd$	Z,N,V	1
CLR	Rd	Clear Register	$Rd \leftarrow Rd \oplus Rd$	Z,N,V	1
SER	Rd	Set Register	$Rd \leftarrow 0xFF$	None	1
MUL	Rd, Rr	Multiply Unsigned	$R1:R0 \leftarrow Rd \times Rr$	Z,C	2
MULS	Rd, Rr	Multiply Signed	$R1:R0 \leftarrow Rd \times Rr$	Z,C	2
MULSU	Rd, Rr	Multiply Signed with Unsigned	$R1:R0 \leftarrow Rd \times Rr$	Z,C	2
FMUL	Rd, Rr	Fractional Multiply Unsigned	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	Z,C	2
FMULS	Rd, Rr	Fractional Multiply Signed	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	Z,C	2
FMULSU	Rd, Rr	Fractional Multiply Signed with Unsigned	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	Z,C	2
<b>BRANCH INSTRUCTIONS</b>					
RJMP	k	Relative Jump	$PC \leftarrow PC + k + 1$	None	2
IJMP		Indirect Jump to (Z)	$PC \leftarrow Z$	None	2
RCALL	k	Relative Subroutine Call	$PC \leftarrow PC + k + 1$	None	3
ICALL		Indirect Call to (Z)	$PC \leftarrow Z$	None	3
RET		Subroutine Return	$PC \leftarrow \text{STACK}$	None	4
RETI		Interrupt Return	$PC \leftarrow \text{STACK}$	I	4
CPSE	Rd,Rr	Compare, Skip if Equal	if ( $Rd = Rr$ ) $PC \leftarrow PC + 2$ or 3	None	1/2/3
CP	Rd,Rr	Compare	$Rd - Rr$	Z, N,V,C,H	1
CPC	Rd,Rr	Compare with Carry	$Rd - Rr - C$	Z, N,V,C,H	1
CPI	Rd,K	Compare Register with Immediate	$Rd - K$	Z, N,V,C,H	1
SBRC	Rr, b	Skip if Bit in Register Cleared	if ( $(Rr(b)=0)$ ) $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBRS	Rr, b	Skip if Bit in Register is Set	if ( $(Rr(b)=1)$ ) $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBIC	P, b	Skip if Bit in I/O Register Cleared	if ( $(P(b)=0)$ ) $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBIS	P, b	Skip if Bit in I/O Register is Set	if ( $(P(b)=1)$ ) $PC \leftarrow PC + 2$ or 3	None	1/2/3
BRBS	s, k	Branch if Status Flag Set	if ( $SREG(s) = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRBC	s, k	Branch if Status Flag Cleared	if ( $SREG(s) = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BREQ	k	Branch if Equal	if ( $Z = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRNE	k	Branch if Not Equal	if ( $Z = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRCS	k	Branch if Carry Set	if ( $C = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRCC	k	Branch if Carry Cleared	if ( $C = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRSH	k	Branch if Same or Higher	if ( $C = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRLO	k	Branch if Lower	if ( $C = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRMI	k	Branch if Minus	if ( $N = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRPL	k	Branch if Plus	if ( $N = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRGE	k	Branch if Greater or Equal, Signed	if ( $(N \oplus V) = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRLT	k	Branch if Less Than Zero, Signed	if ( $(N \oplus V) = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRHS	k	Branch if Half Carry Flag Set	if ( $H = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRHC	k	Branch if Half Carry Flag Cleared	if ( $H = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRTS	k	Branch if T Flag Set	if ( $T = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRTC	k	Branch if T Flag Cleared	if ( $T = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRVS	k	Branch if Overflow Flag is Set	if ( $V = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRVC	k	Branch if Overflow Flag is Cleared	if ( $V = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRIE	k	Branch if Interrupt Enabled	if ( $I = 1$ ) then $PC \leftarrow PC + k + 1$	None	1/2
BRID	k	Branch if Interrupt Disabled	if ( $I = 0$ ) then $PC \leftarrow PC + k + 1$	None	1/2
<b>BIT AND BIT-TEST INSTRUCTIONS</b>					
SBI	P,b	Set Bit in I/O Register	$I/O(P,b) \leftarrow 1$	None	2
CBI	P,b	Clear Bit in I/O Register	$I/O(P,b) \leftarrow 0$	None	2
LSL	Rd	Logical Shift Left	$Rd(n+1) \leftarrow Rd(n), Rd(0) \leftarrow 0$	Z,C,N,V	1
LSR	Rd	Logical Shift Right	$Rd(n) \leftarrow Rd(n+1), Rd(7) \leftarrow 0$	Z,C,N,V	1
ROL	Rd	Rotate Left Through Carry	$Rd(0) \leftarrow C, Rd(n+1) \leftarrow Rd(n), C \leftarrow Rd(7)$	Z,C,N,V	1
ROR	Rd	Rotate Right Through Carry	$Rd(7) \leftarrow C, Rd(n) \leftarrow Rd(n+1), C \leftarrow Rd(0)$	Z,C,N,V	1
ASR	Rd	Arithmetic Shift Right	$Rd(n) \leftarrow Rd(n+1), n=0..6$	Z,C,N,V	1
SWAP	Rd	Swap Nibbles	$Rd(3..0) \leftarrow Rd(7..4), Rd(7..4) \leftarrow Rd(3..0)$	None	1
BSET	s	Flag Set	$SREG(s) \leftarrow 1$	SREG(s)	1
BCLR	s	Flag Clear	$SREG(s) \leftarrow 0$	SREG(s)	1
BST	Rr, b	Bit Store from Register to T	$T \leftarrow Rr(b)$	T	1
BLD	Rd, b	Bit load from T to Register	$Rd(b) \leftarrow T$	None	1
SEC		Set Carry	$C \leftarrow 1$	C	1
CLC		Clear Carry	$C \leftarrow 0$	C	1
SEN		Set Negative Flag	$N \leftarrow 1$	N	1
CLN		Clear Negative Flag	$N \leftarrow 0$	N	1



Mnemonics	Operands	Description	Operation	Flags	#Clocks
SEZ		Set Zero Flag	$Z \leftarrow 1$	Z	1
CLZ		Clear Zero Flag	$Z \leftarrow 0$	Z	1
SEI		Global Interrupt Enable	$I \leftarrow 1$	I	1
CLI		Global Interrupt Disable	$I \leftarrow 0$	I	1
SES		Set Signed Test Flag	$S \leftarrow 1$	S	1
CLS		Clear Signed Test Flag	$S \leftarrow 0$	S	1
SEV		Set Twos Complement Overflow.	$V \leftarrow 1$	V	1
CLV		Clear Twos Complement Overflow	$V \leftarrow 0$	V	1
SET		Set T in SREG	$T \leftarrow 1$	T	1
CLT		Clear T in SREG	$T \leftarrow 0$	T	1
SEH		Set Half Carry Flag in SREG	$H \leftarrow 1$	H	1
CLH		Clear Half Carry Flag in SREG	$H \leftarrow 0$	H	1

**DATA TRANSFER INSTRUCTIONS**

MOV	Rd, Rr	Move Between Registers	$Rd \leftarrow Rr$	None	1
MOVW	Rd, Rr	Copy Register Word	$Rd+1:Rd \leftarrow Rr+1:Rr$	None	1
LDI	Rd, K	Load Immediate	$Rd \leftarrow K$	None	1
LD	Rd, X	Load Indirect	$Rd \leftarrow (X)$	None	2
LD	Rd, X+	Load Indirect and Post-Inc.	$Rd \leftarrow (X), X \leftarrow X + 1$	None	2
LD	Rd, -X	Load Indirect and Pre-Dec.	$X \leftarrow X - 1, Rd \leftarrow (X)$	None	2
LD	Rd, Y	Load Indirect	$Rd \leftarrow (Y)$	None	2
LD	Rd, Y+	Load Indirect and Post-Inc.	$Rd \leftarrow (Y), Y \leftarrow Y + 1$	None	2
LD	Rd, -Y	Load Indirect and Pre-Dec.	$Y \leftarrow Y - 1, Rd \leftarrow (Y)$	None	2
LDD	Rd,Y+q	Load Indirect with Displacement	$Rd \leftarrow (Y + q)$	None	2
LD	Rd, Z	Load Indirect	$Rd \leftarrow (Z)$	None	2
LD	Rd, Z+	Load Indirect and Post-Inc.	$Rd \leftarrow (Z), Z \leftarrow Z+1$	None	2
LD	Rd, -Z	Load Indirect and Pre-Dec.	$Z \leftarrow Z - 1, Rd \leftarrow (Z)$	None	2
LDD	Rd, Z+q	Load Indirect with Displacement	$Rd \leftarrow (Z + q)$	None	2
LDS	Rd, k	Load Direct from SRAM	$Rd \leftarrow (k)$	None	2
ST	X, Rr	Store Indirect	$(X) \leftarrow Rr$	None	2
ST	X+, Rr	Store Indirect and Post-Inc.	$(X) \leftarrow Rr, X \leftarrow X + 1$	None	2
ST	-X, Rr	Store Indirect and Pre-Dec.	$X \leftarrow X - 1, (X) \leftarrow Rr$	None	2
ST	Y, Rr	Store Indirect	$(Y) \leftarrow Rr$	None	2
ST	Y+, Rr	Store Indirect and Post-Inc.	$(Y) \leftarrow Rr, Y \leftarrow Y + 1$	None	2
ST	-Y, Rr	Store Indirect and Pre-Dec.	$Y \leftarrow Y - 1, (Y) \leftarrow Rr$	None	2
STD	Y+q,Rr	Store Indirect with Displacement	$(Y + q) \leftarrow Rr$	None	2
ST	Z, Rr	Store Indirect	$(Z) \leftarrow Rr$	None	2
ST	Z+, Rr	Store Indirect and Post-Inc.	$(Z) \leftarrow Rr, Z \leftarrow Z + 1$	None	2
ST	-Z, Rr	Store Indirect and Pre-Dec.	$Z \leftarrow Z - 1, (Z) \leftarrow Rr$	None	2
STD	Z+q,Rr	Store Indirect with Displacement	$(Z + q) \leftarrow Rr$	None	2
STS	k, Rr	Store Direct to SRAM	$(k) \leftarrow Rr$	None	2
LPM		Load Program Memory	$R0 \leftarrow (Z)$	None	3
LPM	Rd, Z	Load Program Memory	$Rd \leftarrow (Z)$	None	3
LPM	Rd, Z+	Load Program Memory and Post-Inc	$Rd \leftarrow (Z), Z \leftarrow Z+1$	None	3
SPM		Store Program Memory	$(Z) \leftarrow R1:R0$	None	-
IN	Rd, P	In Port	$Rd \leftarrow P$	None	1
OUT	P, Rr	Out Port	$P \leftarrow Rr$	None	1
PUSH	Rr	Push Register on Stack	$STACK \leftarrow Rr$	None	2
POP	Rd	Pop Register from Stack	$Rd \leftarrow STACK$	None	2

**MCU CONTROL INSTRUCTIONS**

NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep function)	None	1
WDR		Watchdog Reset	(see specific descr. for WDR/timer)	None	1
BREAK		Break	For On-chip Debug Only	None	N/A



## 7. Ordering Information

### 7.1 ATmega88PA

Speed (MHz) <sup>(3)</sup>	Power Supply	Ordering Code <sup>(2)</sup>	Package <sup>(1)</sup>	Operational Range
20	1.8 - 5.5	ATmega88PA-AU ATmega88PA-MMH <sup>(4)</sup> ATmega88PA-MU ATmega88PA-PU	32A 28M1 32M1-A 28P3	Industrial (-40°C to 85°C)

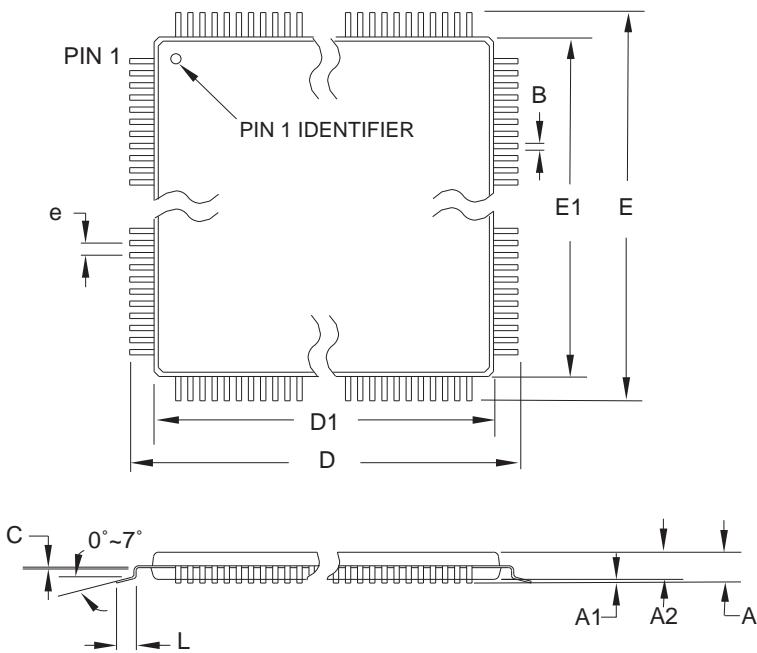
Note:

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. See "Speed Grades" on page 297.
4. NiPdAu Lead Finish.

Package Type	
32A	32-lead, Thin (1.0 mm) Plastic Quad Flat Package (TQFP)
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45 mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50 mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
28P3	28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)

## 8. Packaging Information

### 8.1 32A



**COMMON DIMENSIONS**  
(Unit of Measure = mm)

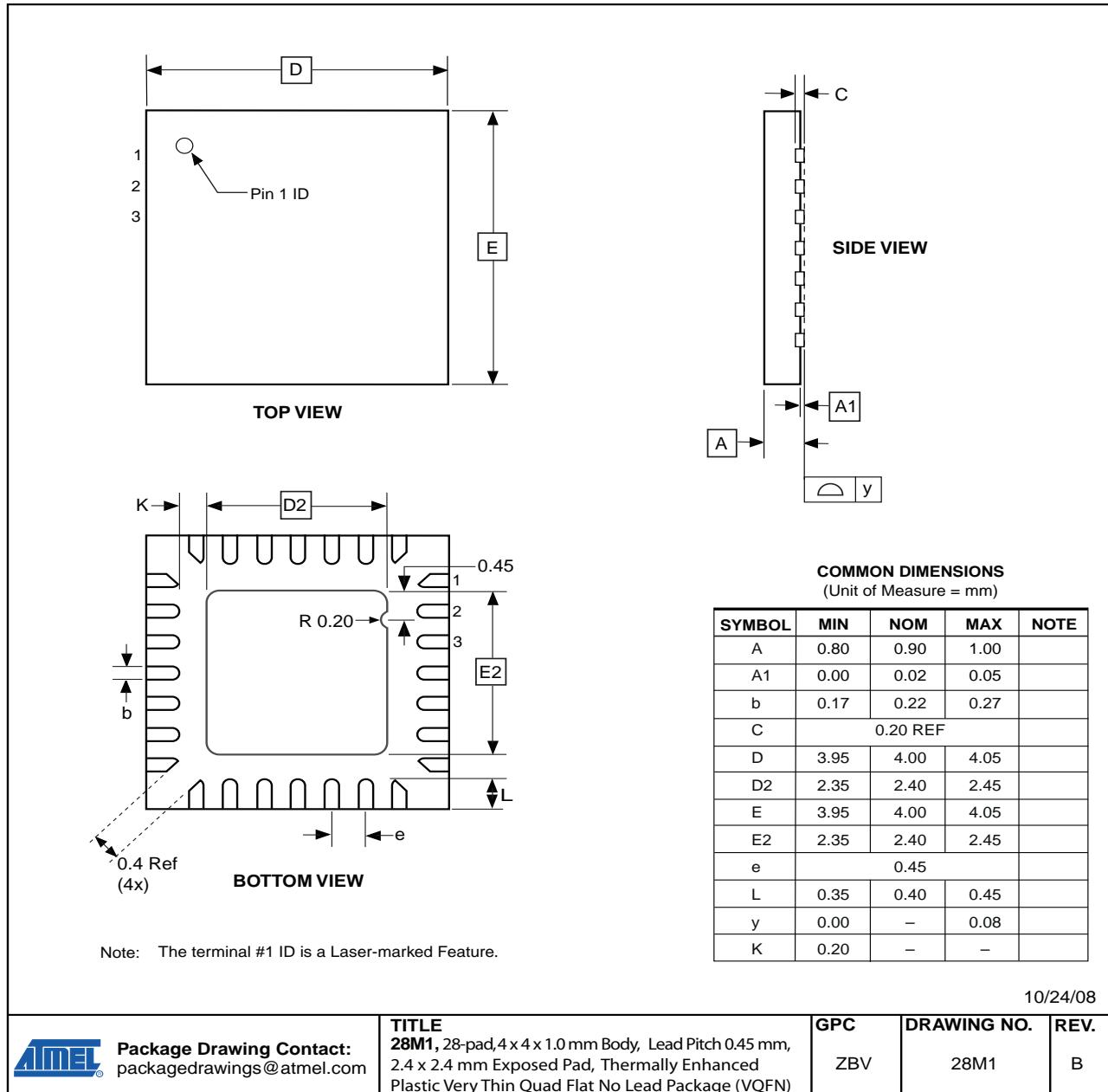
SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	1.20	
A1	0.05	—	0.15	
A2	0.95	1.00	1.05	
D	8.75	9.00	9.25	
D1	6.90	7.00	7.10	Note 2
E	8.75	9.00	9.25	
E1	6.90	7.00	7.10	Note 2
B	0.30	—	0.45	
C	0.09	—	0.20	
L	0.45	—	0.75	
e	0.80 TYP			

- Notes:
- This package conforms to JEDEC reference MS-026, Variation ABA.
  - Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25 mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
  - Lead coplanarity is 0.10 mm maximum.

10/5/2001

2325 Orchard Parkway San Jose, CA 95131	TITLE <b>32A, 32-lead, 7 x 7 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)</b>	DRAWING NO.	REV.
<b>ATMEL</b>		32A	B

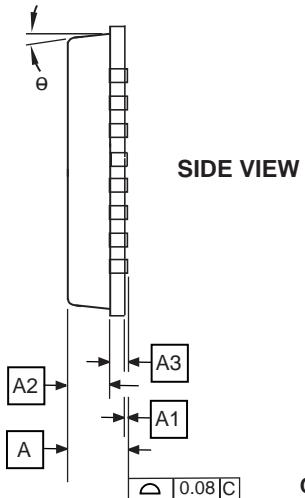
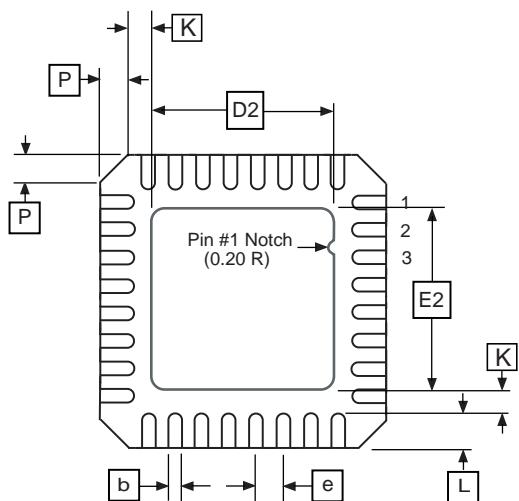
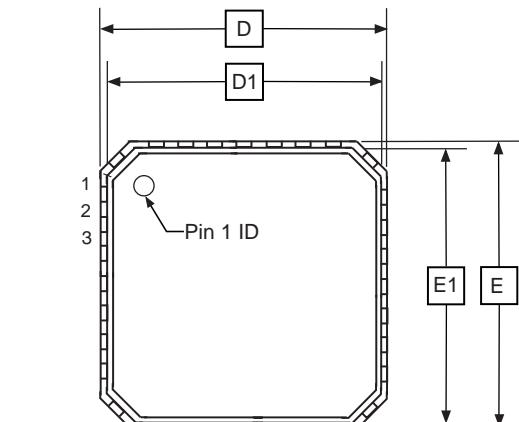
## 8.2 28M1



10/24/08

PACKAGE DRAWING CONTACT: packagedrawings@atmel.com	TITLE 28M1, 28-pad, 4x4x1.0 mm Body, Lead Pitch 0.45 mm, 2.4 x 2.4 mm Exposed Pad, Thermally Enhanced Plastic Very Thin Quad Flat No Lead Package (VQFN)	GPC ZBV	DRAWING NO. 28M1	REV. B
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## 8.3 32M1-A



**COMMON DIMENSIONS**  
(Unit of Measure = mm)

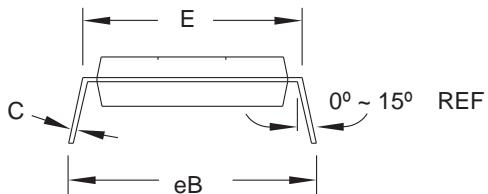
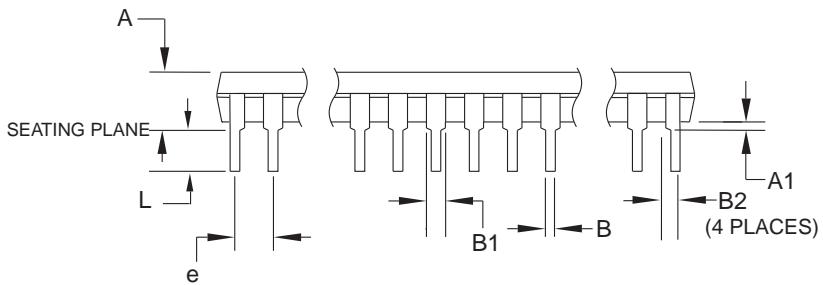
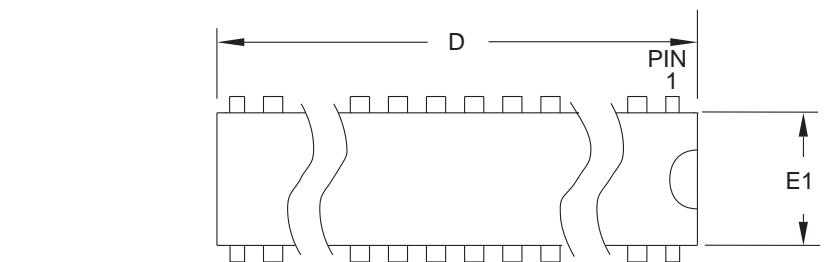
SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	—	0.02	0.05	
A2	—	0.65	1.00	
A3      0.20 REF				
b	0.18	0.23	0.30	
D	4.90	5.00	5.10	
D1	4.70	4.75	4.80	
D2	2.95	3.10	3.25	
E	4.90	5.00	5.10	
E1	4.70	4.75	4.80	
E2	2.95	3.10	3.25	
e      0.50 BSC				
L	0.30	0.40	0.50	
P	—	—	0.60	
θ	—	—	12°	
K	0.20	—	—	

Note: JEDEC Standard MO-220, Fig. 2 (Anvil Singulation), VHHD-2.

5/25/06

ATMEL	2325 Orchard Parkway San Jose, CA 95131	TITLE 32M1-A, 32-pad, 5 x 5 x 1.0 mm Body, Lead Pitch 0.50 mm, 3.10 mm Exposed Pad, Micro Lead Frame Package (MLF)	DRAWING NO. 32M1-A	REV. E
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## 8.4 28P3



**COMMON DIMENSIONS**  
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	-	-	4.5724	
A1	0.508	-	-	
D	34.544	-	34.798	Note 1
E	7.620	-	8.255	
E1	7.112	-	7.493	Note 1
B	0.381	-	0.533	
B1	1.143	-	1.397	
B2	0.762	-	1.143	
L	3.175	-	3.429	
C	0.203	-	0.356	
eB	-	-	10.160	
e	2.540 TYP			

Note: 1. Dimensions D and E1 do not include mold Flash or Protrusion.  
Mold Flash or Protrusion shall not exceed 0.25 mm (0.010").

09/28/01

ATMEL	2325 Orchard Parkway San Jose, CA 95131	TITLE 28P3, 28-lead (0.300"/7.62 mm Wide) Plastic Dual Inline Package (PDIP)	DRAWING NO.	REV.
			28P3	B

## 9. Errata

### 9.1 Errata ATmega88PA

The revision letter in this section refers to the revision of the ATmega88PA device.

#### 9.1.1 Rev. F

No known errata.

## 10. Datasheet Revision History

Please note that the referring page numbers in this section are referred to this document. The referring revision in this section are referring to the document revision.

### 10.1 Rev. 8161A – 11/08

1. Initial revision (Based on the ATmega48P/88P/168P/328P datasheet 8025F-AVR-08/08).
2. Changes done compared to ATmega48P/88P/168P/328P datasheet 8025F-AVR-08/08:
  - Updated "[DC Characteristics](#)" on page [295](#) with new typical values for  $I_{CC}$ .
  - Updated "[Speed Grades](#)" on page [297](#).
  - New graphics in "[Typical Characteristics](#)" on page [307](#).
  - New "[Ordering Information](#)" on page [13](#).



## Headquarters

**Atmel Corporation**  
2325 Orchard Parkway  
San Jose, CA 95131  
USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 487-2600

## International

**Atmel Asia**  
Unit 1-5 & 16, 19/F  
BEA Tower, Millennium City 5  
418 Kwun Tong Road  
Kwun Tong, Kowloon  
Hong Kong  
Tel: (852) 2245-6100  
Fax: (852) 2722-1369

**Atmel Europe**  
Le Krebs  
8, Rue Jean-Pierre Timbaud  
BP 309  
78054 Saint-Quentin-en-Yvelines Cedex  
France  
Tel: (33) 1-30-60-70-00  
Fax: (33) 1-30-60-71-11

**Atmel Japan**  
9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
Tel: (81) 3-3523-3551  
Fax: (81) 3-3523-7581

## Product Contact

**Web Site**  
[www.atmel.com](http://www.atmel.com)

**Technical Support**  
[avr@atmel.com](mailto:avr@atmel.com)

**Sales Contact**  
[www.atmel.com/contacts](http://www.atmel.com/contacts)

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